



CALIFORNIA STATEWIDE UTILITY CODES AND STANDARDS PROGRAM

2016 Title 24 Codes & Standards Enhancement (CASE) Proposal

Residential Lighting

CEC Pre-rulemaking Workshop, June 24th, 2014

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Background - Current Code Requirements

- **All fixtures categorized as high or low efficacy (Table 150.0-A)**

High Efficacy	Low Efficacy
Pin-based linear or compact fluorescent	High efficacy lamps installed in low efficacy luminaires
Pulse-start metal halide	Incandescent
High pressure sodium	Mercury vapor
GU-24 sockets	Track lighting
LED sources certified to the Commission	LED sources not certified to the Commission
Induction	



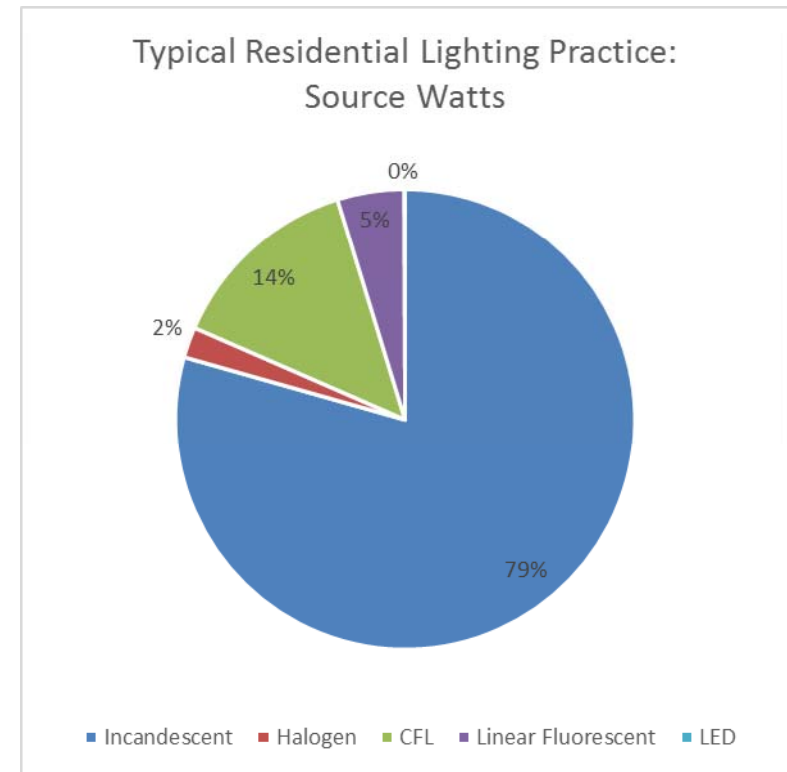
Background - Current Code Requirements

- **Kitchens: at least 50% of Wattage is high efficacy**
 - Requires luminaire wattage calculations and luminaire labelling, see Section 130.0 for details
 - Added low efficacy lighting: 50 watts for dwelling units $\leq 2,500$ ft² or 100 watts for dwelling units $> 2,500$ ft² if lighting on dimmer or occupancy sensor
- **Cabinet lighting: no more than 20W per linear foot of cabinet**
 - Requires a lighting calculation, see Section 130.0
- **Bathrooms:**
 - At least one high efficacy fixture
 - All other fixtures high efficacy or vacancy sensor controlled
- **Garages, Laundry Rooms, and Utility Rooms:**
 - High efficacy AND vacancy controlled
- **All other rooms:**
 - High efficacy, OR
 - Controlled by dimmer or vacancy sensor



Typical Practice – Problem Statement

- **High efficacy lighting has been cost effective since the 2005 Standards**
- **Adoption of high efficacy lighting is still low**
- **Energy savings from low efficacy lighting with controls is far less than the savings from high efficacy lighting**



Source: Efficiency Characteristics and Opportunities for New California Homes, 2011

Note: Source Watts and not number of fixtures



Typical Practice

- **Low Efficacy Residential Lighting**
 - 81% of installed watts are low efficacy
 - 62% of installed lamps are low efficacy
 - 70% of sockets are low efficacy
 - Based on current Title 24 Standards
 - ~ 8% of sockets have high efficacy screw-in lamps

		High Efficacy	Low Efficacy
Average Installed Watts	n	363	1602
	%	19%	81%
Average Installed Lamps	n	17.2	27.4
	%	38%	62%
Average Installed Sockets	n	13.3	31.2
	%	30%	70%



Barriers to High Efficacy Lighting

- **Quality of high efficacy sources**
 - Color quality is a common complaint for CFLs
- **Limited high efficacy fixture choices**
- **Inflexible and unfamiliar sources**
 - GU-24 or pin-base CFL
 - Integral LED luminaires
- **Higher costs for currently defined high efficacy luminaires**
 - Higher costs for luminaires
 - Higher costs for replacement lamps



New Opportunities

- **High quality, high efficacy LED sources**
 - Higher color rendering (90+ CRI)
 - CCT similar to incandescent (2700-3000K)
 - Long life (10+ years in residential applications)
 - Rapidly decreasing costs
- **Federal and State Lamp Standards**
 - Phasing out traditional low efficacy lamps
 - Scheduled to go into effect earlier in California 2018 than rest of country



Proposed Code Change: Simplify the Residential Lighting Standards

- **Require High Efficacy**
 - In all room types
 - Eliminate low efficacy allowances with controls
- **Relax High Efficacy Definition**
 - Allow traditional (e.g. screw-base) socket types, but only if installed with high quality, high efficacy, JA-8 source
 - All hardwired or GU-24 options in Table 150.0-A remain
- **Recessed Downlights only luminaire type not allowed to use JA-8 compliant screw base lamps**
 - JA8 dedicated luminaire, or use quick-connect or Zhaga base
- **Maintain Existing Control Requirements**
 - At least one luminaire in Bathrooms, Laundry, Utility Rooms, and Garages must be controlled by vacancy sensor
 - Dimmers or vacancy sensors required for screw-base LED fixtures in all room types other than Kitchens, Bathrooms, Laundry Rooms, Utility Rooms, and Garages



Proposed Code Change – Energy Savings

- **Whole House Current Practice**
 - 1602 low efficacy watts
 - 1.7 hours per day average, 621 hours per year
 - 988 kWh/year/unit from low efficacy lighting
- **Potential Energy Savings: 625 kWh/yr/unit**
 - Assume 73% savings from downlight requirement
 - Assume 60% savings switching all other lighting from low to high efficacy

Sources: Efficiency Characteristics and Opportunities for New California Homes, 2011;
KEMA 2010 Upstream Lighting Evaluation



Proposed Code Change – Cost Effectiveness

- **Whole House Current Practice**
 - 15.9 average low efficacy downlights
 - 21 average non-downlight low efficacy sockets
- **Incremental Construction Cost: \$525/home**
 - Assumes \$21.60 per compliant downlight
 - Projected 2017 cost, based on decreases in LED costs
 - Incremental costs even less for LED kits with integral trim ring
 - Assumes \$8.64 per lamp, current 90+ CRI LED lamp
 - Projected 2017 cost, based on decreases in LED costs
 - Avoided cost of trim rings, traditional lamps: \$160
- **Incremental Maintenance Costs: -\$132/home**
 - Replace LED's on 24th year: PV \$258
 - A lamps replaced each 3rd year, PAR replaced each 4th year PV \$390
- **Total Present Valued Incremental Costs: \$365**
- **TDV\$ Energy and PV Maintenance Savings: \$2,396/home**
 - Based on 625 kWh/year savings
 - 30 year period of analysis
- **Benefit/Cost Ratio: $2,396 / 365 = 6.56$**



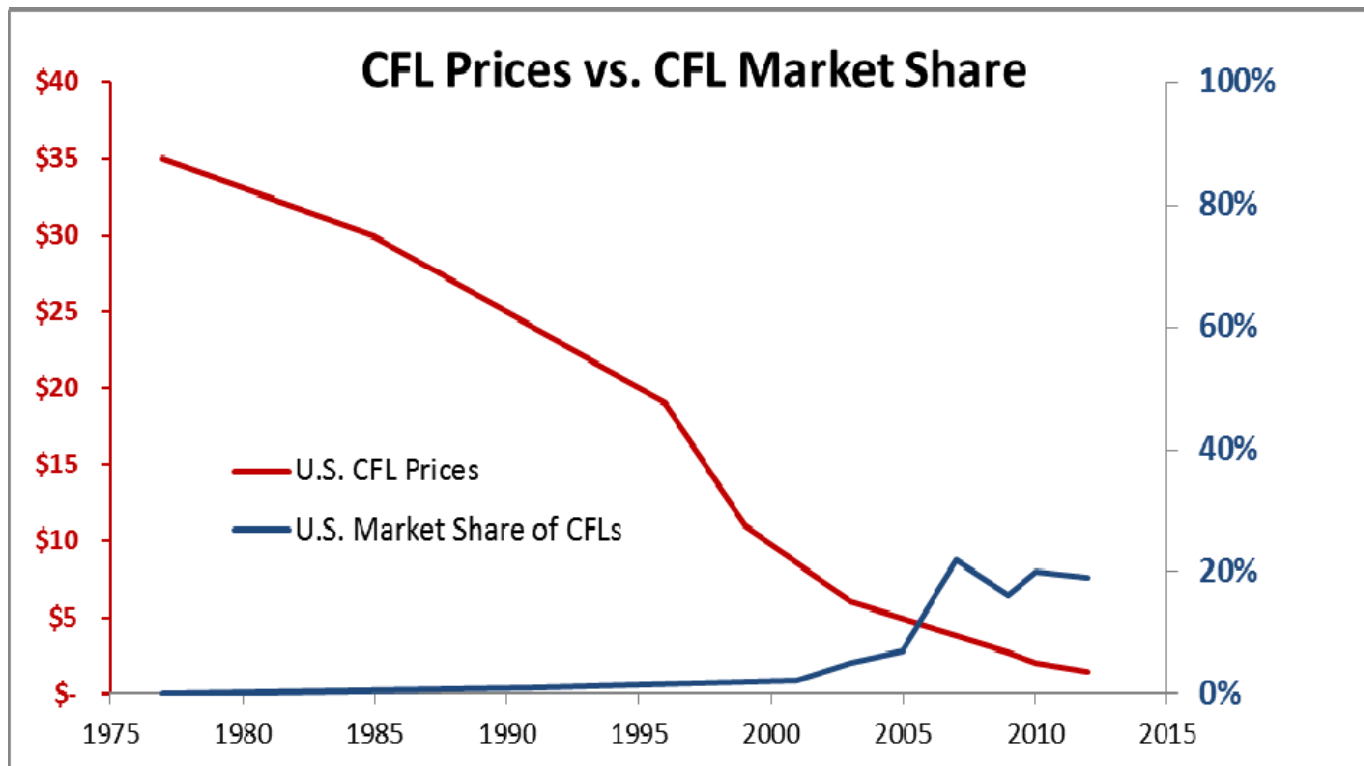
Proposed Code Change – Benefits

- **Affordable, High Quality, High Efficacy**
 - CASE proposal incremental construction cost: ~\$365
 - All hardwired LED incremental costs: \$2375-4400*
 - LED costs expected to continue to decrease
- **Fixture and lamp choice flexibility**

*Source: CLTC and PG&E All High Efficacy Lighting Program



Why the Focus on Quality? Look at CFLs



Sources: PNNL (for DOE), June 2006, "Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market"; D&R International (for DOE), Sept 2010, Energy Star CFL Market Profile; & Presenter's market research; Cadmus (for CPUC), April 2010, "Compact Fluorescent Lamps Market Effects Final Report"



The Problem with CFLs

- **Common findings from studies fit in 3 categories:**

- 1992 EPRI; Perceptions of Compact Fluorescent Lamps in the Residential Market
- 1993 LRC; Quality vs Economy in Home Lighting: How Can we Find the Balance?
- 1993 LRC; Residential Lighting Incentive Programs: What are the Alternatives to Compact Fluorescent Lamps
- 1997 (HMG for) CEC; Lighting Efficiency Technology Report
- 1999: NEEA; LightWise; Market Progress Evaluation Report #1
- 2003: LRC; Increasing Market Acceptance of Compact Fluorescent Lamps
- 2006: PNNL for DOE; Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market
- 2010: Cadmus for CPUC; Compact Fluorescent Lamps Market Effects Final Report

Theme	Specific Concerns
Compatibility	CFLs don't fit in existing sockets, and are not compatible with existing sockets with dimmers.
Light Quality	CFLs have poor light levels and harsh, cold, or "unfriendly" light. CFLs provide inconsistent light color. Consumers experience headaches under fluorescent lighting.
Performance	CFLs don't live up to their long life claims; early failure. CFLs buzz, hum, or flicker. CFLs have a delayed start and a slow run up time (to full brightness).

- **People don't like them**

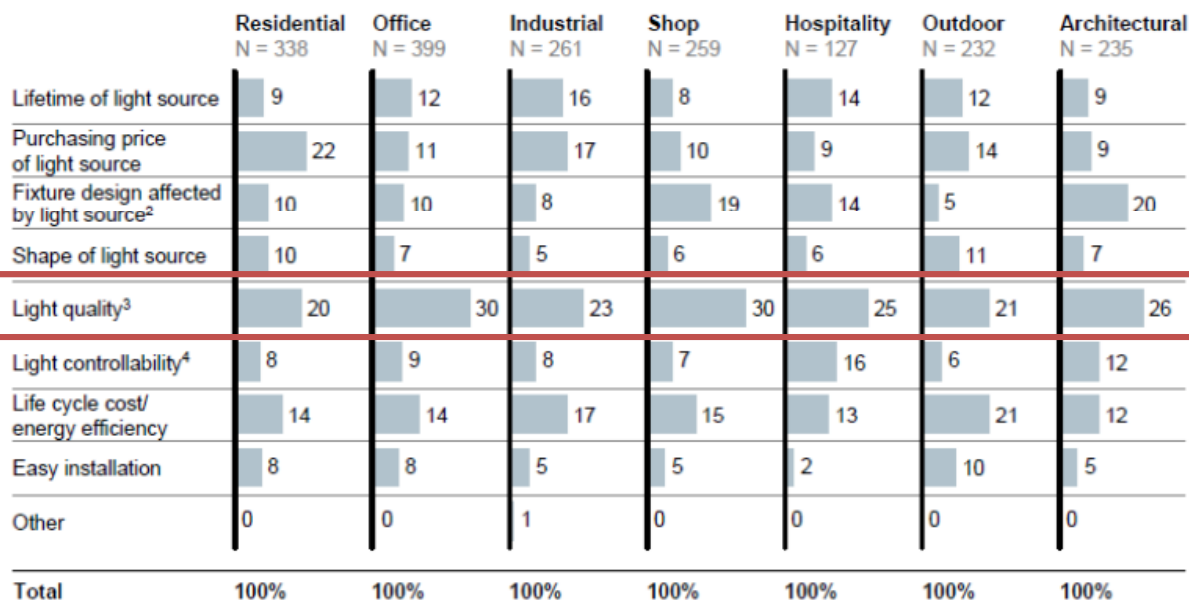


Consumer Preference and Color Quality

McKinsey & Company. *Lighting the Way: Perspectives on the Global Lighting Market*. July 2011

Decision criteria for fixture installation in new buildings/structures

What are the most important criteria when deciding on the type of light source technology in a new fixture installation?
Percent; No. of respondents¹ who selected this response as their 1st decision criterion



¹ 1 respondent could answer up to 3 applications in the survey

² Incl. design flexibility

³ CRI, color temperature, color consistency, and light distribution

⁴ Dimmability, color controllability, etc.

- International survey based on over 650 lighting professionals
- Over 1,000 lighting product consumers
- Light quality is ranked high on lighting selection criteria, in all sectors

¹ Lighting Research Center, Increasing Market Acceptance of Compact Fluorescent Lamps (U.S. Environmental Protection Agency, September 30, 2003), <http://www.lrc.rpi.edu/programs/lightingTransformation/colorRoundTable/pdf/MarketAcceptanceOfCFLsFinal.pdf>.



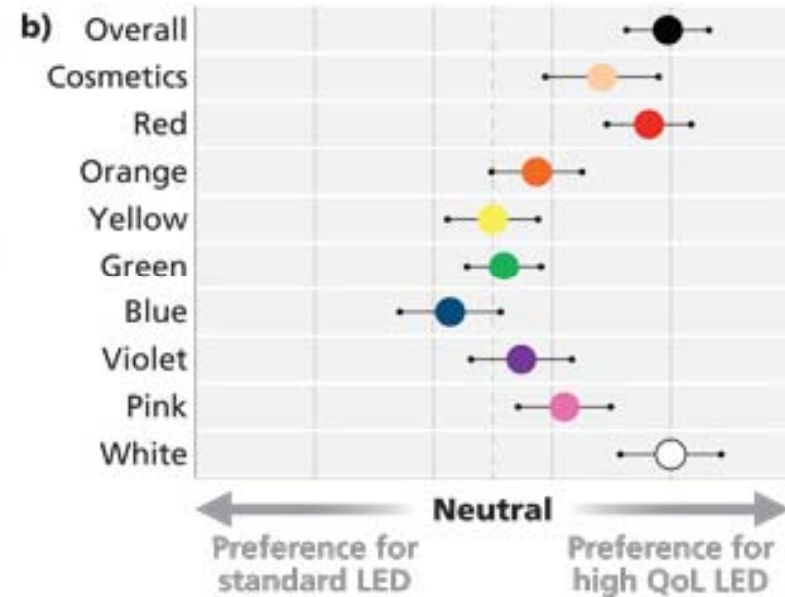
Southern California Edison LED Trial Study

- **In 2011-2012, SCE funded a study into the LED market and consumer preference.**
 - Market Pricing Trial at 117 large national retail locations
 - Focus Groups
 - In-Home Customer Lamp Trial
 - In-Depth Interviews
- **Noteworthy Conclusions**
 - **LEDs linked to CFLs in consumers' minds**
 - **LED market is very price sensitive**
 - **Influencing sales vs. influencing consumer satisfaction**
 - “High sales volumes in the early months after the introduction of a new product category or reduced price are not predictive of sales in later months. Sales can slow after the initial surge.”
 - “Participants in the in-home trial conveyed a number of dissatisfying aspects of LED products once installed in their homes, some of which were light quality issues.”
 - “The goal of influencing consumers to purchase existing ambient LED products can dominate the vision of the industry. Perhaps an equally desirable goal would be to prevent consumer dissatisfaction with ambient LED products once installed.”
 - “It could do harm to the reputation of LED technology to compromise the drive toward higher quality and efficacies. That high pursuit has promise to achieve greater long term market penetration, rather than the short-lived profits of products at lower prices and quality.”



Penn State 2014 Study on LED Color Quality

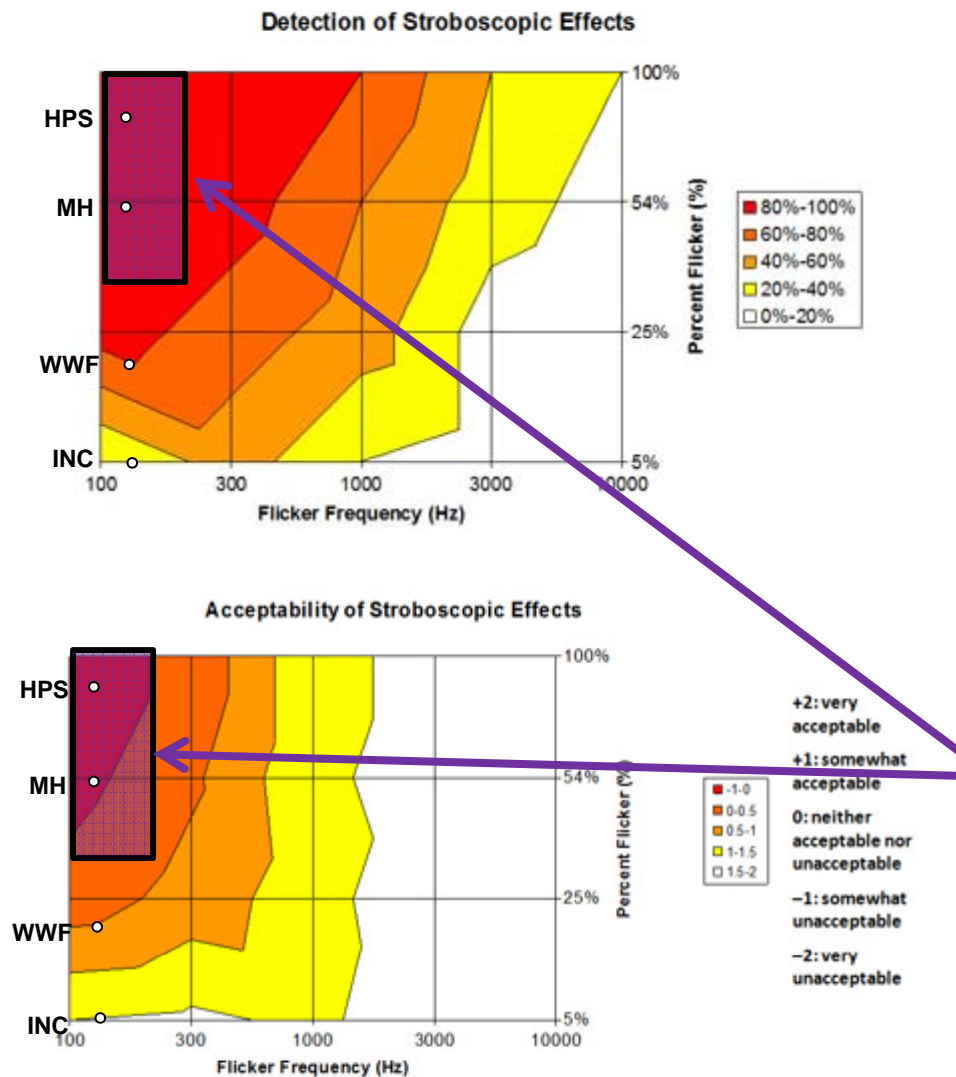
- Recent Penn State study compared high CRI LED (97Ra, 88 R9) to lower CRI LED (84 Ra, 24R9) and found that participants easily perceived a difference and preferred the high quality option — both for viewing colors and whites.



<http://www.ledsmagazine.com/content/leds/en/articles/print/volume-11/issue-4/features/technology/led-advancements-drive-quality-of-light-gains.html>



LRC 2011 Study on Perceptible Flicker



- Detection and acceptability of flicker is a function of frequency and percent flicker (amplitude modulation)
- Red in top figure is most noticeable flicker
- Red in bottom figure is most unacceptable
- Rectangular boxes represents current T-20 definition of what is not an acceptable amount of flicker for control devices.



Appendix JA8

- **Joint Appendix JA8 will continue to be used to house requirements for lamps qualifying as high efficacy, high quality light sources**
- **Will be technology neutral – not just LED's**
- **Will include replacement lamps, regardless of base type**
- **Appendix JA8 currently includes:**
 - 90 CRI – *propose to maintain*
 - 2700-4000K for indoor – *propose to be capable of providing 3000K or less (color changing products allowed) regardless of where used*
 - 2700-5000K for outdoor – *propose to remove outdoor designation*
 - *Non JA-8 sources can comply for outdoor lighting see Table 150.0-A*
 - Minimum efficacy based on wattage – *propose to maintain*

TABLE JA-8 HIGH EFFICACY QUALIFICATION REQUIREMENTS FOR LUMINAIRES OR LIGHT ENGINES USING LED LIGHT SOURCES

Power Rating per Integral LED Luminaire, or per LED Light Engine Under Test	Minimum Efficacy (Lumens Per Watt)
5 watts or less	30
over 5 watts to 15 watts	45
over 15 watts to 40 watts	60
over 40 watts	90



Proposed Revisions to JA-8

- **Proposed new requirements – modeled after CEC Quality Spec, Title 20 proposal, and ENERGY STAR**
 - Color Temperature (CCT) capable of providing ≤ 3000 Kelvin
 - Duv: Must be capable of providing light close to the black body locus, with ± 0.002 in the 1976 CIE color space
 - Color rendering R_9 value (red) at least 50
 - Dimmable to 10%
 - “Reduced flicker operation” between 100% and 20% light output
 - $< 30\%$ percent flicker at frequencies less than 200 Hz
 - No noise above 24dBA, when tested at 100% and 20% of full light output.
 - Power Factor > 0.90
 - Start time < 0.3 seconds
 - Elevated Temperature: Same as ENERGY STAR light output ratio, but for all lamps (90% lumens at 45C)

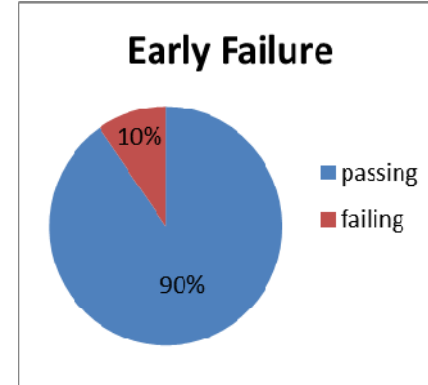
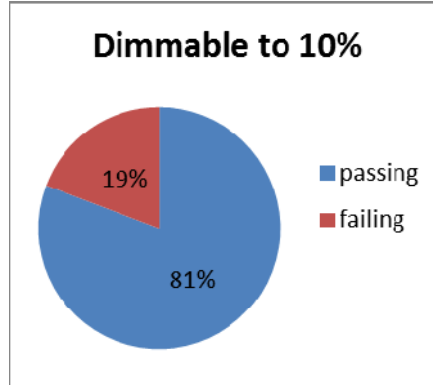
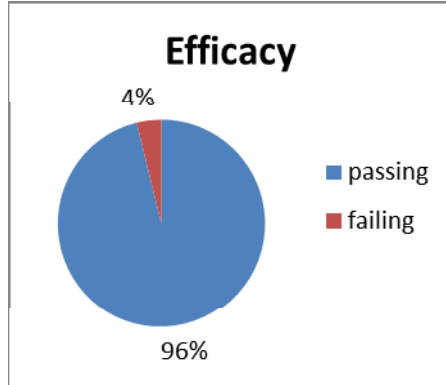
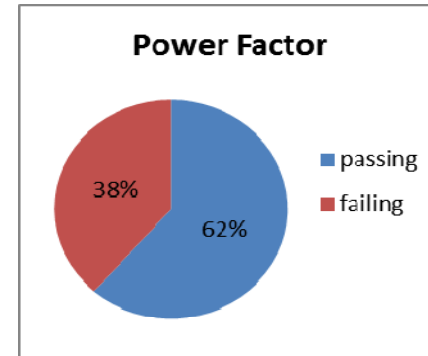
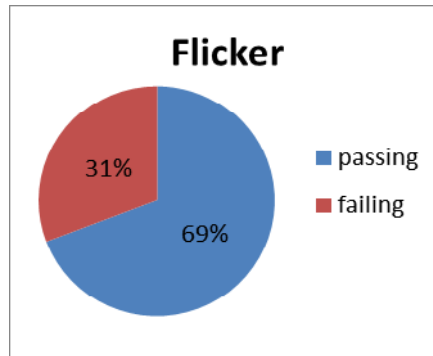
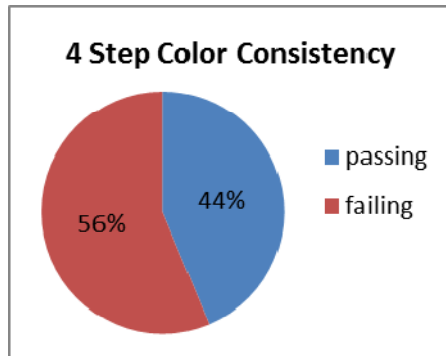


Proposed Revisions to JA-8 (continued)

- **Life Related Requirements**
 - Early Failure: 9 out of 10 lamps operational at 3,000 hr
 - Minimum Rated Lifetime: 15,000 hrs,
 - Lumen Maintenance: At least 86.7% at 6,000 hrs,
 - 5 year manufacturer warranty (based on 1,200 h/yr)
- **Compatibility (LED only):**
 - LED sources complying with JA8 must meet NEMA SSL7A as Type 1 or Type 2 products.
- **Certification and Labeling:**
 - Labeled as meeting JA-8 high quality specification along with other specific lamp markings (wattage, luminous flux, CCT, CRI).
 - Certified in CA appliance efficiency database
 - Labeled with manufacture date



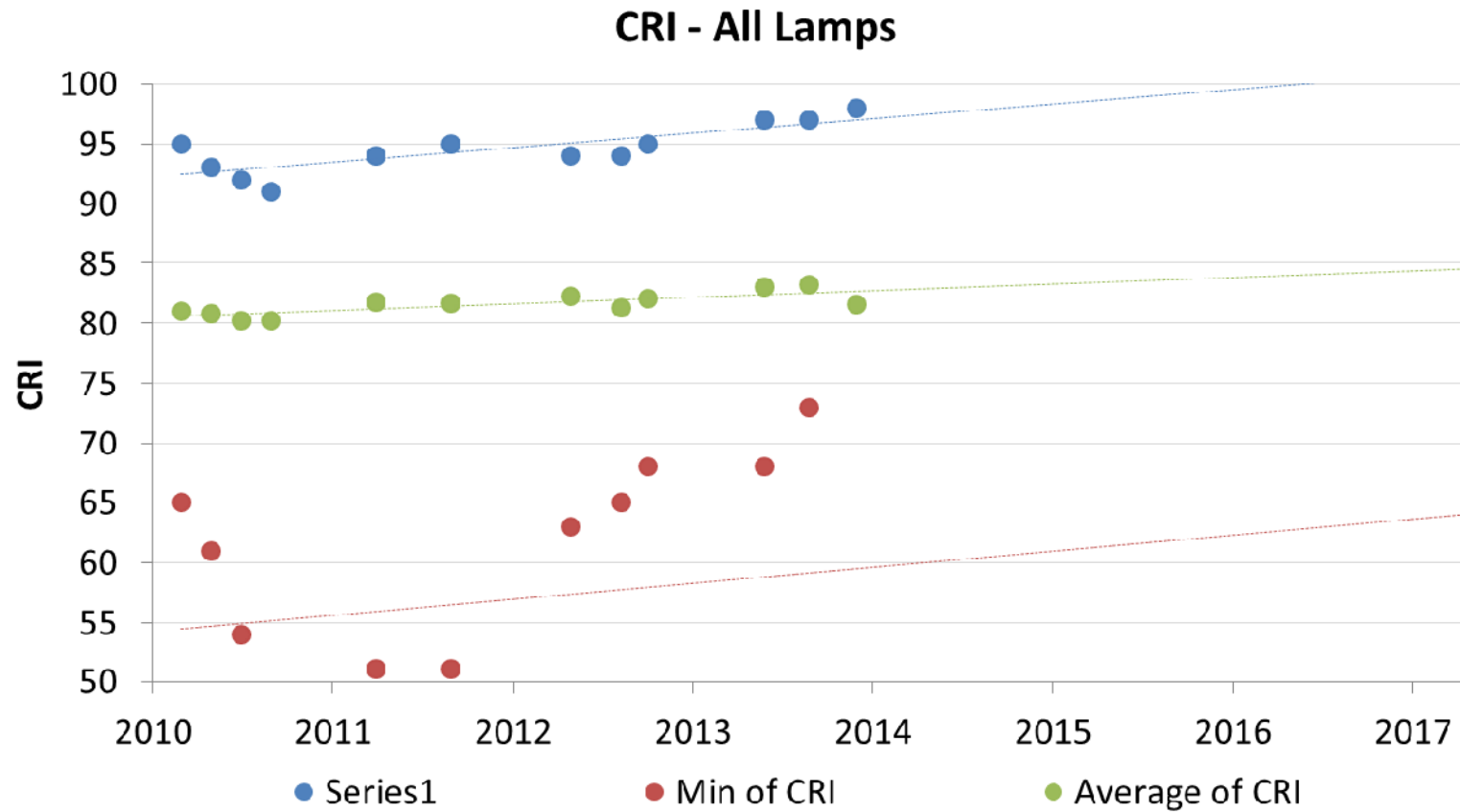
Snapshot of CLTC Test Results – 2013



On behalf of PG&E, CLTC is implementing an ongoing testing program to assess performance and quality of LED replacement lamps, including both directional and omni-directional lamps.

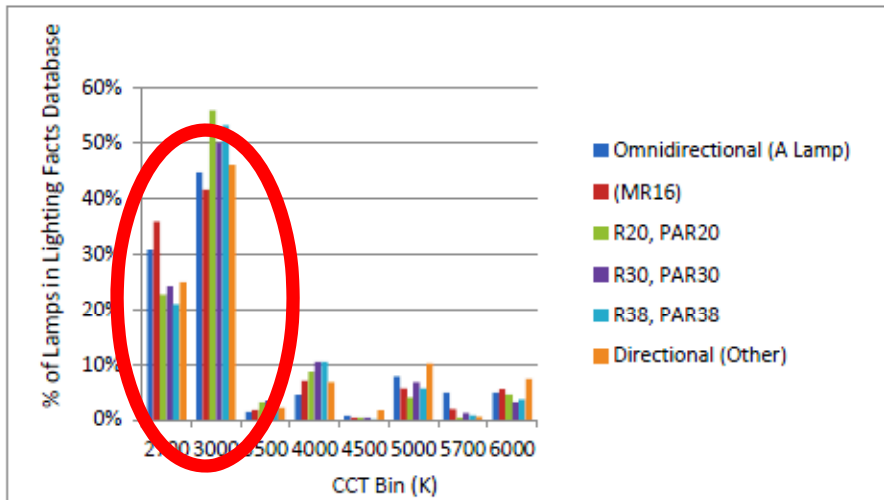


CRI Trends over time – Lighting Facts Data





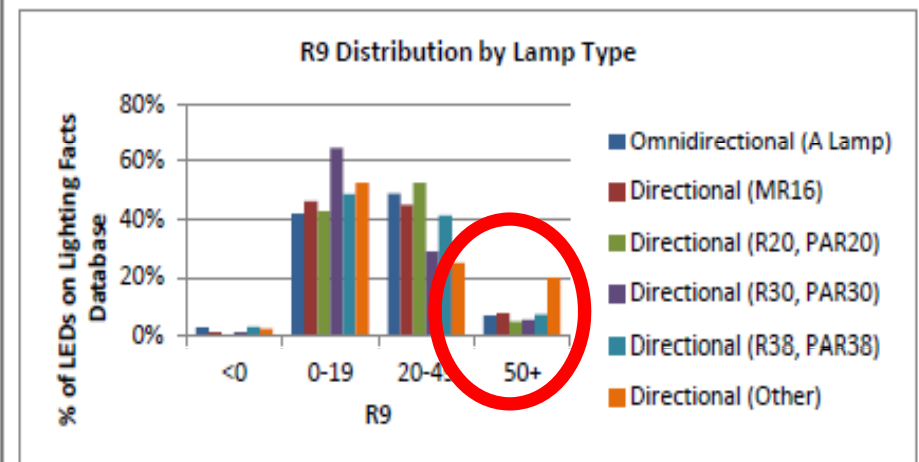
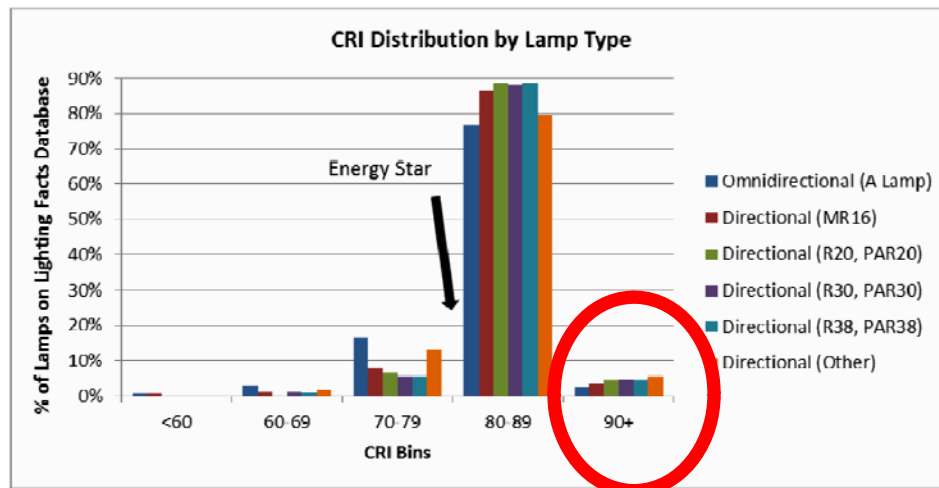
CCT, CRI market share



Color Temperature – Market already primarily 2700-3000K

CRI (Ra): High CRI values in ~5% of market, but increasing

CRI (R9): High R9 values in 5-10% of products, but increasing





Enforcement

- **All luminaires are high efficacy**
 - Hardwired luminaires (no quality spec except for LEDs)
 - Linear fluorescent, pin based CFL, GU-24 base
 - Luminaires with traditional incandescent bases have CA high eff, high quality lamps during inspection
 - Reduce probability that high efficacy lamps removed by homeowner
 - Lamps are labelled
- **Lighting schedule given to new homeowner**
 - Homeowner aware they are entitled to high efficacy, high quality, long life lamps
 - Prevents removal of high efficacy lamps from the house



Methodology for Savings Analysis

- **Energy and Demand Impacts**
 - Spreadsheet analysis
 - Impacts determined based on lighting inventory data
 - Build on previous CASE efforts, with updated data
- **Cost Effectiveness**
 - Spreadsheet analysis
 - Review calculations from previous CASE efforts
 - Update data and revise as necessary
- **Prototype Buildings**
 - Prototype does not specify room types
 - Average unit based on lighting inventory data
 - Results scaled to prototype building size, if necessary



Initial Data and Findings

- **Fixture and source types**
 - Fixture and source types:
 - Efficiency Characteristics and Opportunities for New California Homes, 2011 (lighting inventory)
 - DOE Residential Lighting End-Use Consumption Study, 2012
 - Utility program data, where available
 - Non-CA data (NEEA Residential Building Stock Assessment, etc.), where applicable
 - Hours of use
 - Final Evaluation Report: Upstream Lighting Program, 2010
 - DOE Residential Lighting End-Use Consumption Study, 2012
- **Other available data sources?**



Energy Savings Findings

	Average Annual Energy Use (kWh/year) per House	Percent of Lighting Watts Impacts by Measure	Impacted Energy Use (kWh/year) per House	Savings from Proposed Measure (kWh/year)	TDV Electricity Savings (kBTU)
Downlights	441	100%	441	322	6,731
All Other Lighting	778	65%	506	303	6,342
TOTAL	1,219	78%	947	625	13,073



Cost Savings Findings

Incremental Construction Costs	Incremental Present Value of Maintenance Costs	Total Incremental Costs	TDV Electricity + Maintenance Cost Savings	Benefit to Cost Ratio
\$365	-\$132	\$365	\$2,396	6.56

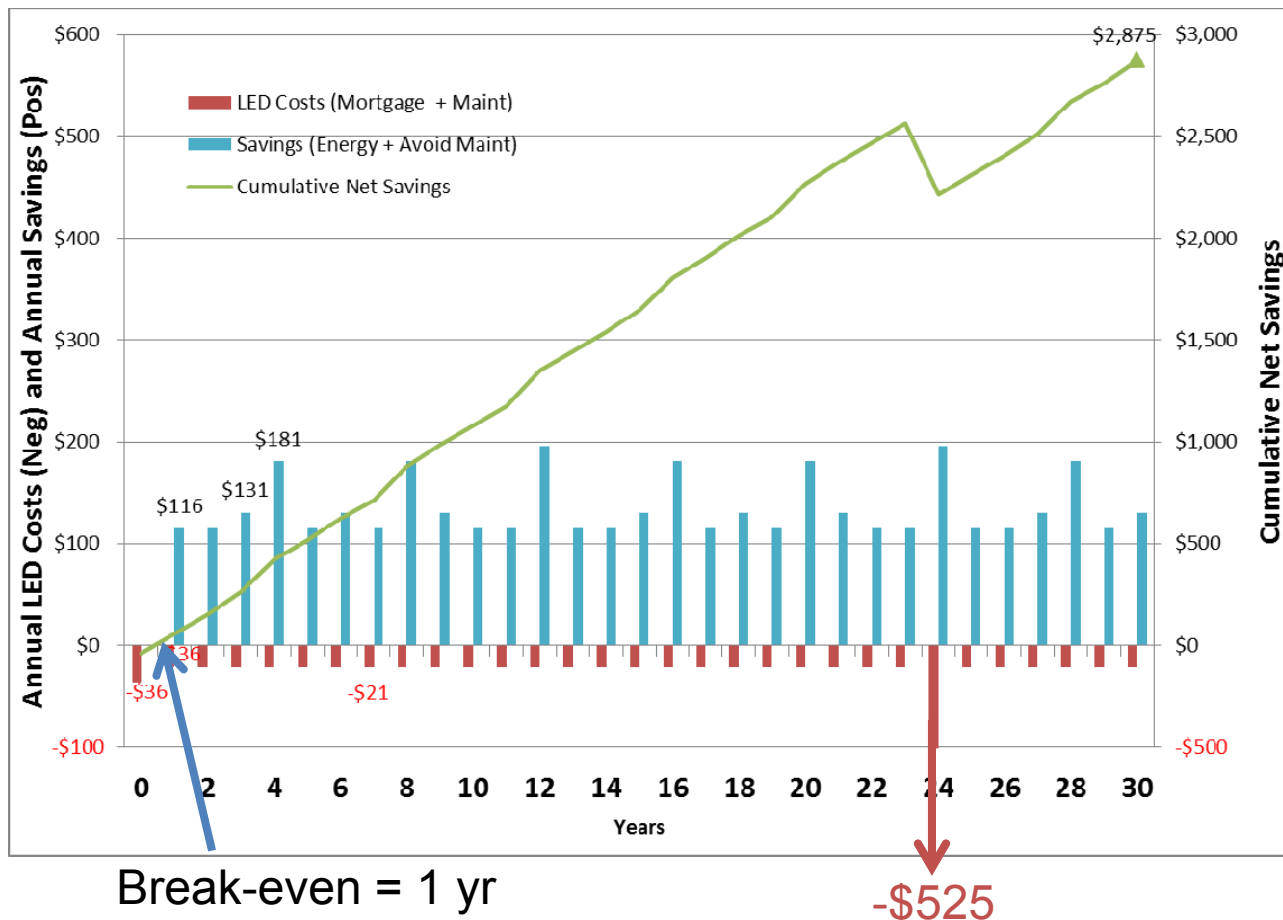
- **Cost basis: 16 recessed luminaires & 21 A lamp sockets**
- **Proposed:**
 - Recessed can retrofit kit = \$21.60/ea
 - Projected 2017 cost, 24 year life @ 15,000 hours
 - A lamp LED replacement = \$8.64/ea
 - Projected 2017 cost, 24 year life @ 15,000 hours)
 - Present value maintenance cost = \$258 (assumes LED cost doesn't drop)
- **Base Case:**
 - Recessed: Par 30 Lamp = \$3.00 (4 yr life – 2,500 hr), white trim ring = \$5.00,
 - Incandescent A lamp = \$0.72 (3 yr life – 2,000 hr)
 - Present Value maintenance cost = \$390



Consumer Cash Flow Impacts

Break even after 1 year, \$2,875 net savings in 30 yr

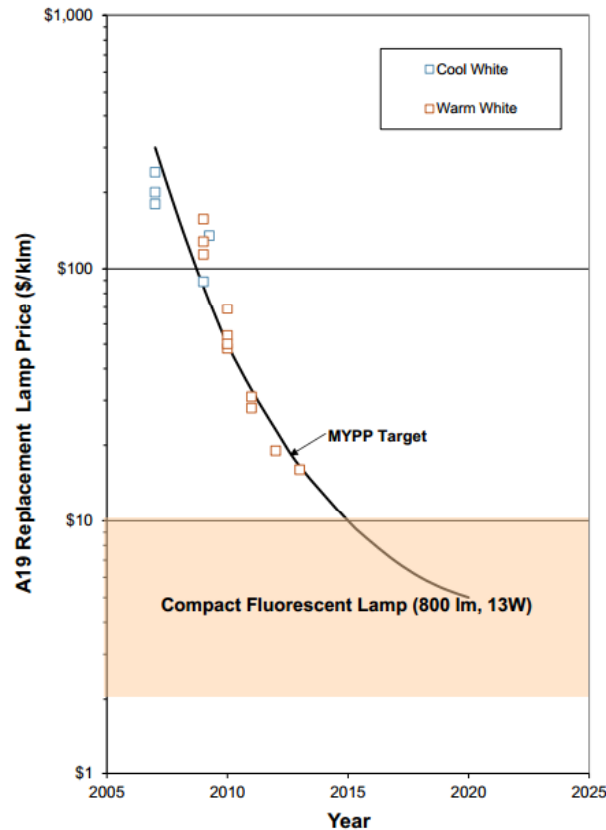
Net first cost = \$364 10% down payment = \$36 Principal = \$328
5% Interest Loan Period = 30 years Annual loan payment = \$21/yr
Annual Energy Cost Savings = \$116 Replace LED in 24 years at \$525
Avoided maintenance costs = A lamps (every 3 years) = \$15,
PAR lamps (every 4 years) = \$65





Initial Data and Findings

- **Projections Indicate Prices will Decrease**
 - LED costs projected to be on par with CFL



Source: DOE Solid-State Lighting Program, Multi-Year Program Plan, April 2014



Proposed Code Requirements

- **Changes to Section 150.0(k) Residential Lighting**
 - All high efficacy requirement replaces all room type requirement sections:
 - 150.0(k)3 through 150.0(k)7, and 150.0(k)9
 - At least one luminaire controlled by vacancy sensor required in Bathrooms, Garages, Laundry Rooms, and Utility Rooms
 - Revises controls requirements for Bathrooms
 - Replaces 150.0(k)6 – Lighting in Garages, Laundry Rooms, and Utility Rooms
 - Dimmers or vacancy sensors required for screw-base fixtures with LED lamps in rooms other than Kitchens, Bathrooms, Garages, Laundry Rooms, and Utility Rooms
 - Consistent with existing 150.0(k)7
- **Code language can be collapsed and simplified**



Proposed Code Requirements

- **Changes to Table 150.0-A**
 - Revised to reflect changes in high efficacy definition
- **Table 150.0-B remains unchanged**
- **Changes to Appendix JA-8**
 - As described above



Proposed Code Language: Section 10-103 Compliance Documentation and Section 100.1 – Definitions

SECTION 10-103 – PERMIT, CERTIFICATE, INFORMATIONAL, AND ENFORCEMENT REQUIREMENTS FOR DESIGNERS, INSTALLERS, BUILDERS, MANUFACTURERS, AND SUPPLIERS

(b) Compliance, Operating, Maintenance, and Ventilation Information to be provided by Builder.

1. Compliance information.

- A. For low-rise residential buildings, at final inspection, the enforcement agency shall require the builder to leave in the building, copies of the completed, signed, and submitted compliance documents for the building owner at occupancy. For low-rise residential buildings, such information shall, at a minimum, include copies of all Certificate of Compliance, Certificate of Installation, and Certificate of Verification documentation submitted. The enforcement agency shall require the builder to produce a fixture schedule complying with Section 150.0(k)1H that shall be left at the building for the building owner at occupancy. These documents shall be in paper or electronic format and shall conform to the applicable requirements of Section 10-103(a).

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

COLOR RENDERING INDEX (CRI). The ability of a light source to reflect the color of illuminated objects with fidelity relative to ideal or natural light sources of the same color temperature. CRI is calculated according to CIE 13.3 (1995).

CORRELATED COLOR TEMPERATURE. Description of color of light relative to the chromaticity of the radiative emission of heated black body and reported in temperature units of Kelvin according to CIE15.2004



Proposed Code Language Mark-up

Section 150.0(k)1 Residential Lighting

(k) Residential Lighting.

1. Luminaire Requirements

A. Luminaire Efficacy: All installed ~~Installed~~ luminaires shall be classified as high-efficacy or ~~low-efficacy~~ for compliance with Section 150.0(k) in accordance with TABLE 150.0-A or ~~TABLE 150.0-B~~, as applicable.

~~**B. Hybrid Luminaires:** When a high efficacy and low efficacy lighting system are combined together in a single luminaire, the high efficacy and low efficacy lighting systems shall separately comply with the applicable provisions of Section 150.0(k).~~

~~**B.- Blank Electrical Boxes.** C. Luminaire Wattage and Classification. The Wattage and Classification of permanently installed luminaires in residential kitchens shall be determined in accordance with Section 130.0(c). In residential kitchens, the wattage of e The number of electrical boxes that are more than 5 feet above the finish floor and do not contain a luminaire or other device shall be no greater than the number of bedrooms. These electrical boxes must be served by a dimmer or vacancy sensor control. or where no electrical equipment has been installed, and where the electrical box can be used for a luminaire or a surface mounted ceiling fan, shall be calculated as 180 watts of low efficacy lighting per electrical box.~~

All high efficacy lighting. Number of blank boxes no more than number of bedrooms³⁴



Section 150.0(k)1C Residential Lighting: Recessed Luminaires in Ceilings

C. 8. Recessed Luminaires in Ceilings. Luminaires recessed into ceilings shall meet all of the following requirements:

- i.-A. Be Listed, as defined in Section 100.1, for zero clearance insulation contact (IC) by Underwriters Laboratories or other nationally recognized testing/rating laboratory; and
- ii.-B. Have a label that certifies that the luminaire is airtight with air leakage less than 2.0 CFM at 75 Pascals when tested in accordance with ASTM E283. An exhaust fan housing shall not be required to be certified airtight; and
- iii.-C. Be sealed with a gasket or caulk between the luminaire housing and ceiling, and shall have all air leak paths between conditioned and unconditioned spaces sealed with a gasket or caulk; and
- ~~D. — For recessed compact fluorescent luminaires with ballasts to qualify as high efficacy for compliance with Section 150.0(k), the ballasts shall be certified to the Commission to comply with the applicable requirements in Section 110.9; and~~
- iv.- E. For luminaires with hardwired ballasts or drivers, Allow ballast or driver maintenance and replacement to be readily accessible to building occupants from below the ceiling without requiring the cutting of holes in the ceiling.
- v. Recessed luminaires shall not use screw based lamps and have a JA-8 compliant light source.



Section 150.0(k)1 Residential Lighting (cont)

Screw Based Luminaires and Fixture Schedule

D. Electronic Ballasts. Ballasts for fluorescent lamps rated 13 watts or greater shall be electronic and shall have an output frequency no less than 20 kHz.

E. Night Lights. Permanently installed night lights and night lights integral to installed luminaires or exhaust fans shall be rated to consume no more than five watts of power per luminaire or exhaust fan as determined in accordance with Section 130.0(c). Night lights shall not be required to be controlled by vacancy sensors.

F. Lighting Integral to Exhaust Fans. Lighting integral to exhaust fans shall meet the applicable requirements of Section 150.0(k).

EXCEPTION to Section 150.0(k)1F: Lighting installed by the manufacturer in kitchen exhaust hoods.

G. Screw based luminaires. Screw based luminaires shall meet all the following requirements

- i. the luminaires are not recessed luminaires
- ii. the luminaires contain lamps that comply with Joint Appendix JA-8 and
- iii. the installed lamps are labelled as compliant with JA-8.

EXCEPTION to Section 150.0(k)1G: Luminaires with hard-wired ballasts for high intensity discharge lamps.

H. Fixture schedule. The enforcement agency shall require the builder to leave in the building, copies of the completed, signed fixture schedule of all interior luminaires and the required lamps in compliance with Section 150.0(k) for the use of the building owner at occupancy in accordance with Section 10-103(b).

Fixture schedule so homeowner knows what they are entitled to.



Section 150.0(k)2 Residential Lighting Controls (cont)

Items B through I unchanged

2. Interior Lighting Switching Devices and Controls.

~~A. High efficacy luminaires shall be switched separately from low efficacy luminaires.~~

A. All dimmers shall comply with NEMA standard SSL 7A.

B. Exhaust fans shall be switched separately from lighting systems.

EXCEPTION to Section 150.0(k)2B: Lighting integral to an exhaust fan may be on the same switch as the fan provided the lighting can be switched OFF in accordance with the applicable provisions in Section 150(k)2 while allowing the fan to continue to operate for an extended period of time.

C. Luminaires shall be switched with readily accessible controls that permit the luminaires to be manually switched ON and OFF.

D. Lighting controls and equipment shall be installed in accordance with the manufacturer's instructions.

E. No controls shall bypass a dimmer or vacancy sensor function where that dimmer or vacancy sensor has been installed to comply with Section 150.0(k).

F. Lighting controls shall comply with the applicable requirements of Section 110.9.

G. An Energy Management Control System (EMCS) may be used to comply with dimmer requirements in Section 150.0(k) if at a minimum it provides the functionality of a dimmer in accordance with Section 110.9, meets the installation certificate requirements in Section 130.4, the EMCS requirements in Section 130.5, and complies with all other applicable requirements in Section 150.0(k)2.

H. An Energy Management Control System (EMCS) may be used to comply with vacancy sensor requirements in Section 150.0(k) if at a minimum it provides the functionality of a vacancy sensor in accordance with Section 110.9, meets the installation certificate requirements in Section 130.4, the EMCS requirements in Section 130.5, and complies with all other applicable requirements in Section 150.0(k)2.

I. A multiscene programmable controller may be used to comply with dimmer requirements in Section 150.0(k) if at a minimum it provides the functionality of a dimmer in accordance with Section 110.9, and complies with all other applicable requirements in Section 150.0(k)2.

J. In Bathrooms, attached and detached Garages, Laundry Rooms, and Utility Rooms, at least one luminaire in each of these spaces shall be controlled by a vacancy sensor.

K. All screw based fixtures shall be controlled by a dimmer or a vacancy sensor.

EXCEPTION 1 to Section 150.0(k)2K: Luminaires in closets less than 70 square feet.

EXCEPTION 2 to Section 150.0(k)2K: Luminaires in hallways.

Dimmers are compatible with Solid State Lighting (SSL-7)
Controls very similar to current requirements



Section 150.0(k) Residential Lighting (cont)

Simplification: items 3- 7 deleted, item 8 moved to 1C

~~3. ——— Lighting in Kitchens.~~

~~A. ——— A minimum of 50 percent of the total rated wattage of permanently installed lighting in kitchens shall be high efficacy.~~

~~B. ——— For the purpose of compliance with Section 150.0(k), kitchen lighting includes all permanently installed lighting in the kitchen except for lighting that is internal to cabinets for the purpose of illuminating only the inside of the cabinets. Lighting in areas adjacent to the kitchen, including but not limited to dining and nook areas, are considered kitchen lighting if they are not separately switched from kitchen lighting.~~

~~EXCEPTION to Section 150.0(k)3: Up to 50 watts for dwelling units less than or equal to 2,500 ft² or 100 watts for dwelling units larger than 2,500 ft² may be exempt from the 50 percent high efficacy requirement when all lighting in the kitchen is controlled in accordance with the applicable provisions in Section 150.0(k)2, and is also controlled by vacancy sensors or dimmers.~~

~~4. ——— Lighting Internal to Cabinets. Permanently installed lighting that is internal to cabinets shall use no more than 20 watts of power per linear foot of illuminated cabinet. The length of an illuminated cabinet shall be determined using one of the following measurements, regardless of the number of shelves or the number of doors per cabinet section:~~

~~A. ——— One horizontal length of illuminated cabinet; or~~

~~B. ——— One vertical length, per illuminated cabinet section; or~~

~~C. ——— No more than one vertical length per every 40 horizontal inches of illuminated cabinet.~~

~~5. ——— Lighting in Bathrooms. Lighting installed in bathrooms shall meet the following requirements:~~

~~A. ——— A minimum of one high efficacy luminaire shall be installed in each bathroom; and~~

~~B. ——— All other lighting installed in each bathroom shall be high efficacy or controlled by vacancy sensors.~~

~~6. ——— Lighting in Garages, Laundry Rooms, and Utility Rooms. Lighting installed in attached and detached garages, laundry rooms, and utility rooms shall be high efficacy luminaires and controlled by vacancy sensors.~~

~~7. ——— Lighting other than in Kitchens, Bathrooms, Garages, Laundry Rooms, and Utility Rooms. Lighting installed in rooms or areas other than in kitchens, bathrooms, garages, laundry rooms, and utility rooms shall be high efficacy, or shall be controlled by either dimmers or vacancy sensors.~~

~~EXCEPTION 1 to Section 150.0(k)7: Luminaires in closets less than 70 square feet.~~

~~EXCEPTION 2 to Section 150.0(k)7: Lighting in detached storage buildings less than 1,000 square feet located on a residential site.~~



Section 150.0(k)3 Residential Outdoor Lighting (cont)

Minor clarification and renumbering

3.-9. Residential Outdoor Lighting. In addition to meeting the requirements of Section 150.0(k)1, Luminaires ~~luminaires~~ providing residential outdoor lighting shall meet the following requirements, as applicable:

A. For single-family residential buildings, outdoor lighting permanently mounted to a residential building or other buildings on the same lot ~~shall be high efficacy, or may be low efficacy if it meets all of the following requirements in item (i) and the requirements in either item (ii) or item (iii):~~

- i. Controlled by a manual ON and OFF switch that does not override to ON the automatic actions of items ii or iii below; and
- ii. Controlled by a combined photocell and motion sensor. Controls that override to ON shall not be allowed unless the override shall automatically return the lighting control to its normal operation within 6 hours. not having an override or bypass switch that disables the motion sensor, or controlled by a motion sensor having a temporary override switch which temporarily bypasses the motion sensing function and automatically reactivates the motion sensor within 6 hours
- iii. Controlled by one of the following methods:
 - a. A Photocontrol and time clock control. Controls that override to ON shall not be allowed unless the override shall automatically return the lighting control to its normal operation within 6 hours. not having an override or bypass switch that disables the photocontrol; or
 - b. Astronomical time clock. not having an override or bypass switch that disables the astronomical time clock; Controls that override to ON shall not be allowed unless the override shall automatically return the astronomical to its normal operation within 6 hours and which is programmed to automatically turn the outdoor lighting OFF during daylight hours; or
 - c. Energy management control system which meets all of the following requirements:

At a minimum provides the functionality of an astronomical time clock in accordance with Section 110.9; meets the Installation Certification requirements in Section 130.4; meets the requirements for an EMCS in Section 130.5; does not have an override or bypass switch that allows the luminaire to be always ON; and, is programmed to automatically turn the outdoor lighting OFF during daylight hours.

B. For low-rise multi-family residential buildings, outdoor lighting for private patios, entrances, balconies, and porches; and outdoor lighting for residential parking lots and residential carports with less than eight vehicles per site shall comply with one of the following requirements:

- i. Shall comply with Section ~~150.0(k)3A~~ 150.0(k)3A; or
- ii. Shall comply with the applicable requirements in Sections 110.9, 130.0, 130.2, 130.4, 140.7, and 141.0.

C. For low-rise residential buildings with four or more dwelling units, outdoor lighting not regulated by Section ~~150.0(k)3B~~ 150.0(k)3B or Section ~~150.0(k)3D~~ 150.0(k)3D shall comply with the applicable requirements in Sections 110.9, 130.0, 130.2, 130.4, 140.7, and 141.0.

D. Outdoor lighting for residential parking lots and residential carports with a total of eight or more vehicles per site shall comply with the applicable requirements in Sections 110.9, 130.0, 130.2, 130.4, 140.7, and 141.0.



Proposed Changes to Table 150.0-A

High Efficacy Light Sources

Luminaires ~~manufactured, designed and rated for use~~ installed with only the lighting technologies in this column shall be classified as high efficacy:

1. Pin-based linear or compact fluorescent lamps with electronic ballasts. Compact fluorescent lamps ≥ 13 watts shall have 4 pins for compliance with the electronic ballast requirements in Section 150.0(k)1D.
2. Pulse-start metal halide lamps.
3. High pressure sodium lamps.
4. Luminaires with GU-24 sockets ~~rated for LED lamps.~~
5. ~~GU-24 sockets rated for compact fluorescent lamps.~~
5. Luminaires having an integral light source with a luminous efficacy of at least 45 lm/W. Note that recessed luminaires must also meet the requirements of Reference Joint Appendix JA-8.
6. Luminaires containing lamps or light sources which ~~using LED light sources which have been certified to the Commission as high efficacy in accordance~~ comply with Reference Joint Appendix JA8 and the light sources are labelled as such. Note that recessed luminaires shall not have screw bases regardless of lamp type as described in Section 150.0(k)1C.
7. ~~Luminaire housings rated by the manufacturer for use with only LED light engines.~~
- 7 8. Luminaires with hardwired high frequency generator and induction ~~Induction~~ lamps or induction lamps with a GU-24 base.

Note: Adaptors which convert an incandescent lamp holder to a high-efficacy luminaire shall not be used to classify a luminaire as high efficacy.



Marked-up Code Language

- **Table 150.0-B deleted**



APPENDIX 1-A STANDARDS AND DOCUMENTS REFERENCED IN THE ENERGY EFFICIENCY REGULATIONS

Commission Internationale de l'Eclairage.

- CIE 13.3 (1995). “Method of Measuring and Specifying Colour Rendering Properties of Light Sources”
- CIE 15.2004. Technical Report. “Calorimetry.”
- **Available from:**
 - Commission Internationale de l'Eclairage
 - CIE Central Bureau
Babenbergerstrasse 9/9A
1010 Vienna, AUSTRIA



Appendix JA8 – Qualification Requirements for Residential Luminaires Using LED California High Quality, High Efficacy Light Sources

To qualify as a residential high efficacy luminaire using a California High Quality, High Efficacy Light Emitting Diode (LED) as the light source (as defined in IES LM-80-2008), the LED light engine (as defined in ANSI/IES RP-16-2010) light source (including ballast or driver if applicable) used in the luminaire shall be certified to the Energy Commission according to all of the following requirements, or by a method approved by the Executive Director. If the ~~LED light engine~~ light source is inseparable from the luminaire (for example, an integral LED luminaire) then the entire luminaire shall meet the same requirements. ~~LED light engine(s) and integral LED luminaires(s) are referred to as LED luminaire(s) below.~~

~~(a) Shall be manufactured for use in residential applications. LED luminaires not intended for use in residential applications, LED landscape luminaires, and luminaire housings not containing a light engine shall not be certified to the Energy Commission for the purpose of complying with Joint Appendix JA-8.~~

~~(a)-(b)~~ The efficacy of the light source ~~integral LED luminaire or LED light engine~~ when tested in accordance with the test methods listed in JA-8 item (s), IES LM-79-2008, shall be equal to or greater than the efficacies contained in TABLE JA-8.



Appendix JA8 – Qualification Requirements for Residential Luminaires Using LED California High Quality, High Efficacy Light Sources

~~(b) (c) When designed or rated for indoor use~~ The light source shall be capable of providing a Correlated Color Temperature (CCT) that includes at least one point within the range of 2700K to 4000K that is less than 3000K and with Duv values within the range of +/-0.002 in the 1976 CIE color space. ; when designed or rated for outdoor use shall be capable of providing a nominal CCT that includes at least one point within the range of 2700K to 5000K; with tolerance defined as in ANSI C78-377-2008. Color changing lamps capable of providing light outside of the above defined chromaticity ranges shall also be able to meet all of the requirements in this section when tested within the defined chromaticity ranges.

Exception to Section (c): ~~Monochromatic LEDs that are only for decorative purposes~~

~~(c) (d) Shall be capable of providing~~ Light source shall provide a minimum Color Rendering Index (CRI) of 90 when tested at a CCT less than or equal to 3000K.

Exception 1 to Section (d): ~~Monochromatic LEDs that are only for decorative purposes~~

~~(e) An LED light engine shall be capable of being installed in luminaire housing without using any type of base or socket used for incandescent lamps; it may include a GU-24 or modular quick connect, but shall not include screw base sockets or adaptors of type and size E12 through E39.~~

~~(f) An LED lamp, integrated or non-integrated type in accordance with the definition in ANSI/IES RP-16-2010, shall not be certified to the Energy Commission as a high efficacy luminaire or high efficacy light engine, and shall not be classified as a high efficacy luminaire for compliance with Title 24, Part 6 of the CCR.~~

(d) Light source shall provide color rendering R9 value (red) at least 50 when tested at a CCT less than or equal to 3000K.



Appendix JA8 – Qualification Requirements for Residential Luminaires Using LED California High Quality, High Efficacy Light Sources

- (e) Light source shall be dimmable down to 10% light output.
- (f) Light source shall not emit noise above 24dBA, when tested at 100% and 20% of full light output.
- (g) Light source shall provide “reduced flicker operation” when tested at 100% and 20% of full light output, defined as amplitude modulation (percent flicker) less than 30% at frequencies less than 200Hz, tested according to the requirements in Title 20.
- (h) Light source shall have a Power Factor at least 0.90 tested according to the requirements in Title 20.
- (i) Light source shall have start time no less than 0.3 seconds as tested according to the requirements in Title 20.
- (j) Elevated Temperature Light Output Ratio: When tested at 45°C, the light source shall maintain at least 90% of the initial light output (total luminous flux) measured at ambient temperature (25°C)
- (k) Rated Life: Light source shall have a minimum rated lifetime of 15,000 hrs.
- (l) Lumen Maintenance: Minimum percentage of 0-hour light output after a 6,000 hour test must be 86.7%.
- (m) Early Failure: 9 out of 10 tested units shall be operational at 3,000 hours.
- (n) Warranty: Light source shall have five year manufacturer warranty (based on 1,200 h/yr)
- ~~(g)(o) The integral LED luminaire or LED light engine~~ The light source model under test shall be tested in a Underwriters Laboratory (UL) 1598 testing apparatus in a testing laboratory participating in the ISO/IEC 17025, by the National Voluntary Laboratory Accreditation Program (NVLAP) or other laboratory accreditation body operating in accordance with ISO/IEC 17011 and produced under an ongoing inspection program carried out by a Type A inspection body in accordance with ISO/IEC 17020, accredited to ISO/IEC 17020 by an accreditation body operating in accordance with ISO/IEC 17011.



Appendix JA8 – Qualification Requirements for Residential Luminaires

Simplification: Deleted text

~~(h) Each integral lamp, LED luminaire or LED light engine tested shall produce the same quantity and quality of light. An integral LED luminaire or LED light engine under test producing different Correlated Color Temperature (CCT), Color Rendering Index (CRI), total flux (per linear foot for linear systems) or other quantitative and qualitative differences in light shall be separately tested and separately certified to the Energy Commission.~~

~~(i) A worst case test may be used to certify a group of integral LED luminaires or LED light engines having the same quantity and quality of light in accordance with section (h).~~

~~(j) For determining efficacy, the input wattage of the integral LED luminaire or LED light engine under test shall be determined as follows:~~

- ~~1. For single LED luminaires, use the maximum rated input wattage of the luminaire.~~
- ~~2. When multiple LED light engines are connected to a single power supply, all possible combinations shall be tested to determine the various input wattages and efficacies for the power supply under test. The combination providing the worst case efficacy shall be the system efficacy.~~
- ~~3. LED luminaires, installed on lighting track that is capable of being used with multiple lighting technologies, shall be treated as single LED luminaires in accordance with section (j)1. Lighting track capable of accommodating any non-LED lighting technologies shall not be certified as LED lighting.~~



Appendix JA8 – Qualification Requirements for Residential Luminaires Using LED California High Quality, High Efficacy Light Sources

~~(k)(p) For single LED luminaires, m~~ Maximum rated input wattage, total luminous flux, CCT, and CRI of the integral lamp, LED luminaire or LED light engine light source under test shall be listed on a permanent, ~~pre-printed, factory-installed label on the light source circuit board, light engine, or luminaire light source housing.~~ Product shall contain marking indicating “CA JA8 Compliant.” Product shall contain a marking that indicates the date of manufacture in the following format: “Date of Manuf: MM/YYYY”

(q) LED-based lamps, luminaires, or light engines shall meet the requirements of NEMA’s standard SSL7A as Type 1 or Type 2 products.

~~(l) For LED systems in accordance with section (j)2, all possible wattage combinations, luminous flux, CCT, CRI, and efficacies of each of possible combination of the integral LED luminaire or LED light engine under test shall be listed on a permanent, pre-printed, factory-installed label on the power supply, or published in manufacturer’s catalogs.~~



Appendix JA8 – Qualification Requirements for Residential Luminaires Using LED California High Quality, High Efficacy Light Sources

(r) Test methods for measuring and calculating luminous efficacy of light sources

- i. Incandescent and halogen reflector lamps: IES LM-20-94, “*Photometric Testing of Reflector-Type Lamps – Incandescent Lamps.*”
- ii. Incandescent non-reflector lamps: IES LM-45-2009, “*Method for Electrical and Photometric Measurements of General Service Incandescent Filament Lamps.*”
- iii. Compact fluorescent and Linear fluorescent including U-tube and circleline: IES LM-9-2009, “*Electrical and Photometric Measurements of Fluorescent Lamps.*”
- iv. LED integral lamps, LED light engines and integral LED luminaires: IES LM 79-2008, “*Electrical and Photometric Measurements of Solid-State Lighting Products.*”
- v. High intensity discharge lamps: IES LM-51-13, “*Approved Method for the Electrical and Photometric Measurements of High Intensity Discharge Lamps.*”



Appendix JA8 – Qualification Requirements for Residential Luminaires Using LED California High Quality, High Efficacy Light Sources

TABLE JA-8 HIGH EFFICACY QUALIFICATION REQUIREMENTS ~~FOR~~
~~LUMINAIRES OR LIGHT ENGINES USING LED LIGHT SOURCES~~

Power Rating per <u>Light Source</u> Integral Lamp, LED Luminaire, or LED Light Engine and Driver Under Test	Minimum Efficacy (Lumens Per Watt)
5 watts or less	30
over 5 watts to 15 watts:	45
over 15 watts to 40 watts:	60
over 40 watts:	90



Low flicker operation Test Method

- Requirement for “low flicker operation” has been in Title 24 for a long time.
- Requirement for dimmers and dimming daylighting controls in what is now Section 110.9.
- For the 2013 Standards this requirement was moved to Title 20 Section 1605.3(l)2F2
 - *“Dimmer controls that can directly control lamps shall provide electrical outputs to lamps for reduced flicker operation through the dimming range so that the light output has an amplitude modulation of less than 30 percent for frequencies less than 200 Hz without causing premature lamp failure.”*
 - Up to now no test method
- **New proposal to California Title 20 Appliance Standards:** Proposed Flicker Test Method, similar to EnergyStar test method but requires higher sampling rate and data is filtered before reported.
- http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_CA_IOUs_Response_to_Draft_Regulations_Dimming_Ballasts_Finalv2_2014-06-06_TN-73146.pdf



Proposal for 2014 Title-20 Section 1604(I)3

Section 1604. Test Methods for Specific Appliances

(I) Emergency Lighting and Self-Contained Lighting Controls...

(3) Dimming systems flicker. The test method for components of dimming systems including dimming lamps, dimming ballasts and dimming controls is as follows:

- (A) Equipment Combinations – describes that flicker results are specific to combinations of dimmer, lamp and driver or ballast.
- (B) Test Equipment Requirements – capable of measuring accurately and digitizing waveform of emitted light relative intensity.
- (C) Flicker Test Conditions – input power temperature and thermal conditions. Measurements taken at 100%, 80% 50% and 20% of full light output
- (D) Test Procedure – lamp stabilization, interval and duration of readings.
 - Sampling frequency > 20 kHz, Test duration at least 1 second.
- (E) Calculations – filtering of data (low pass) at 40 Hz, 90 Hz, 200 Hz, 400 Hz and 1,000 Hz and unfiltered. Calculate percent amplitude modulation (percent flicker). Data filtered at 200 Hz is used for Title 24 compliance.
- (F) Test Report and Data Format – report percent flicker and download raw data file.



Summary of Primary Impacts

- Downlights will be required to be JA8 compliant, and not use screw based lamps
 - Can use integral downlight luminaires, or use quick-connect, Zhaga or GU-24 base.
- Any other luminaire / luminaire base type (including medium screw base, GU5.3, GU10, candelabra base, Zhaga, or hard wired integral luminaire) can be classified as a high efficacy luminaire, provided it has a High Efficacy, High Quality Light Source (compliant with JA8) installed at the time of inspection.
- Any type of lamp or light source, regardless of base type or technology, can be eligible to meet JA8, provided it can meet all of the JA8 specs
- GU-24, linear fluorescent, HID and dedicated outdoor luminaires can comply with Section 150.0(k) without being JA-8 compliant



Feedback From IOU Stakeholder Meeting

- IOU Stakeholder meeting was held May 15, 2014
- Stakeholders preferred a requirement for dedicated downlights, rather than allowing JA8 compliant reflector lamps
- Stakeholders expressed support for the emphasis on product quality
- Concerns were raised about cooler color temperatures and negative consumer reactions. Stakeholders also argued that lamps that shift red when dimming (mimicking incandescent) should be allowed, as should other variable CCT products
- Stakeholders pointed out that NEMA SSL7A is not a technology neutral standard and couldn't therefore be required for all sources meeting JA8.
- Notes and presentations from stakeholder meeting available at Title24Stakeholders.com.



Requests from Stakeholders

- **What are your thoughts on the broad outlines of this proposal?**
 - What elements do you like?
 - What elements do you dislike?
- **Additional data sources?**
 - Current practice for permanently installed lighting
 - Hours of use
 - Cost data
 - Consumer response to various elements of lighting quality
 - Surveys, laboratory studies etc.
- **Residential lighting in 2017:**
 - Where is the market going?
 - What types of fixtures and lamps will be available
 - High efficacy in general
 - High quality LED sources



Questions?

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